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Kawashima

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(45) **Date of Patent: Nov. 3, 2015**

(54) **WINDING STRUCTURE, COIL WINDING, COIL PART, AND COIL WINDING MANUFACTURING METHOD**

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(73) Assignee: **SUMIDA CORPORATION** (JP)

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(22) Filed: **Nov. 26, 2013**

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H01F 27/28 (2006.01)
H01F 27/29 (2006.01)
H01F 41/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H01F 27/29*** (2013.01); ***H01F 27/28*** (2013.01); ***H01F 27/2847*** (2013.01); ***H01F 41/0604*** (2013.01); ***H01F 41/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01F 5/00; H01F 27/00–27/30
USPC 336/180–184, 220–223
See application file for complete search history.

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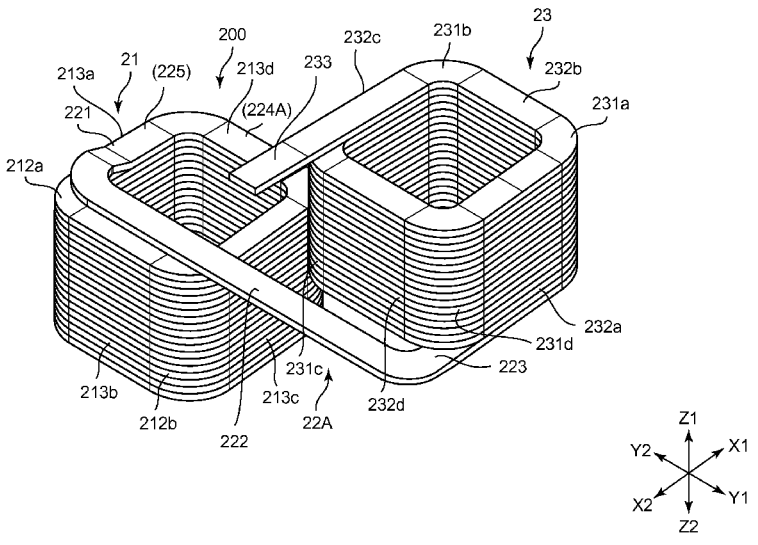
(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

There is provided a winding structure, a coil winding, a coil part, and a coil winding manufacturing method, which are capable of preventing occurrence of an extra space due to existence of a connecting wire part when two winding parts and a connecting wire part connecting the winding parts are formed.

8 Claims, 19 Drawing Sheets



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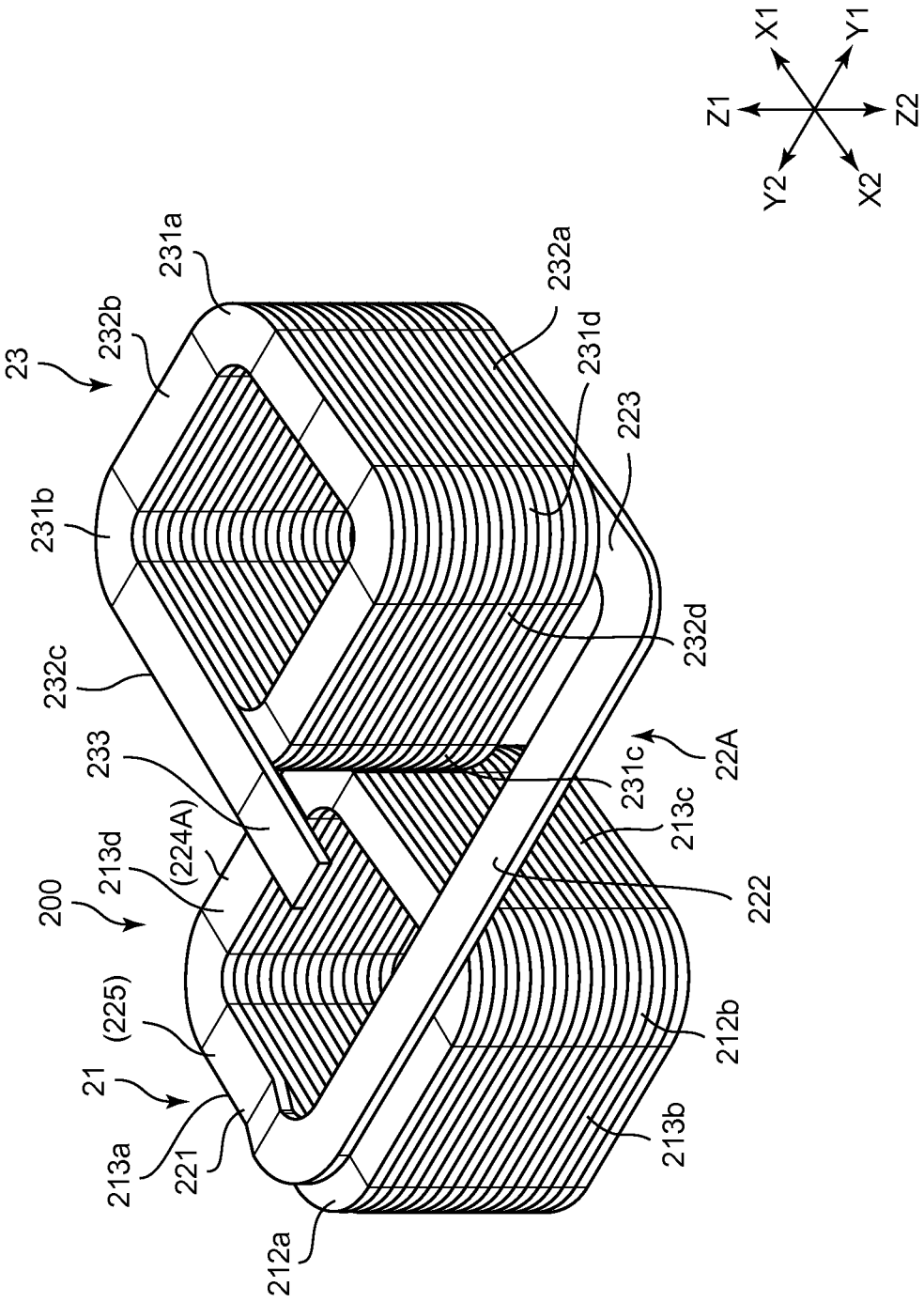
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232a
231d
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231b
232c
232d
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231c
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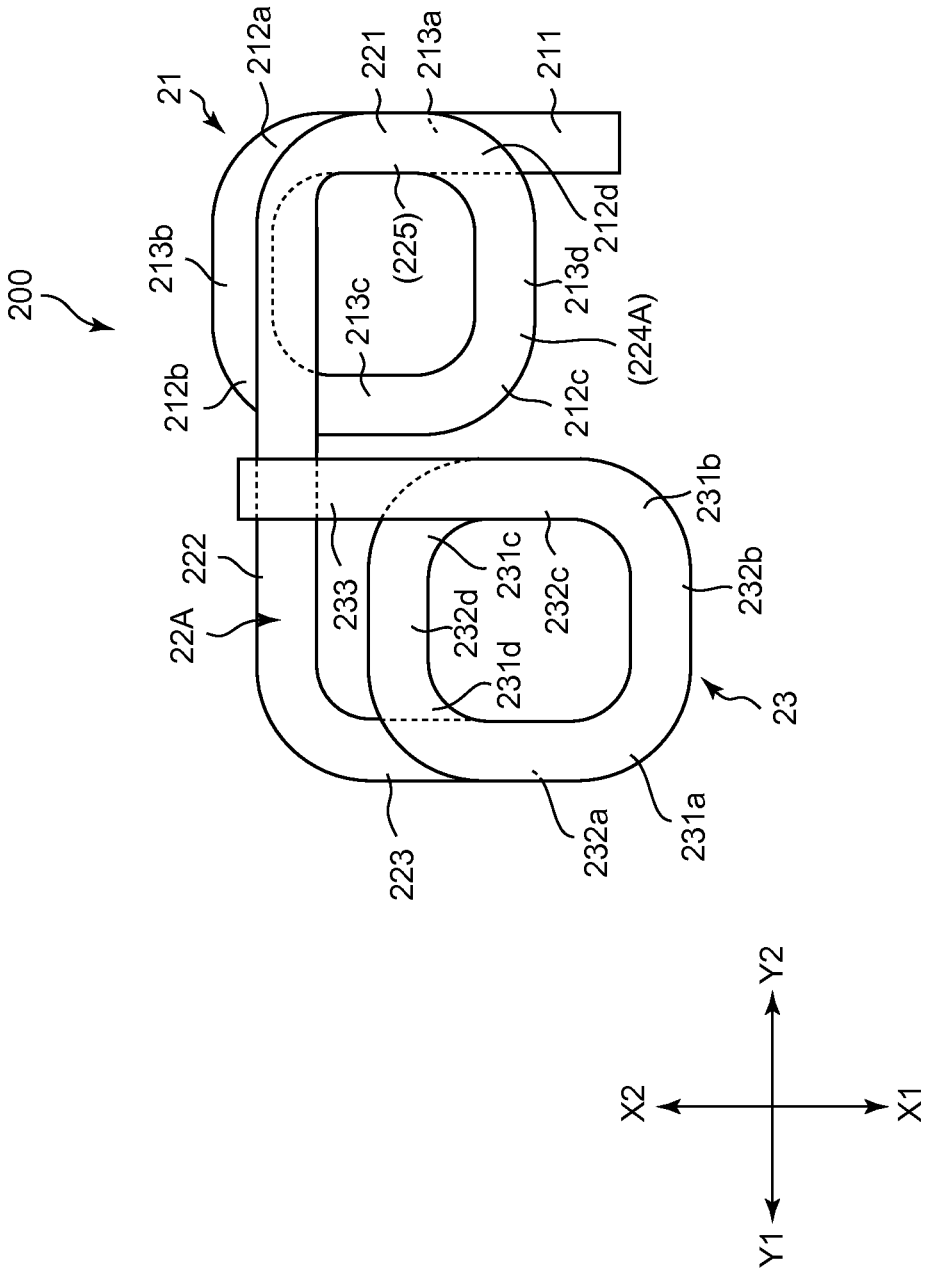
213c
(224A)
213d
200
222
(225)
212b
21
213b
213a
221
212a

Fig.1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232b
231d
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232a
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X2
X1
Y1

Fig.2

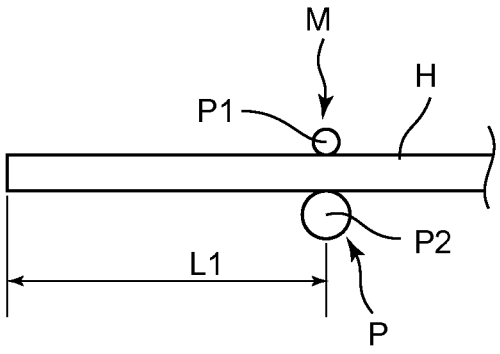


Fig.3A

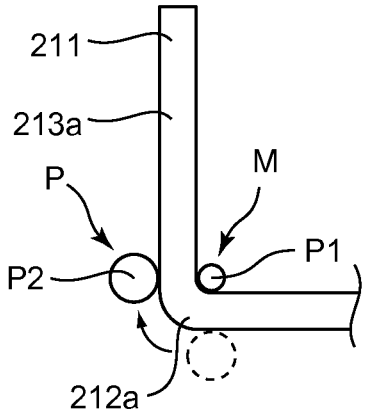
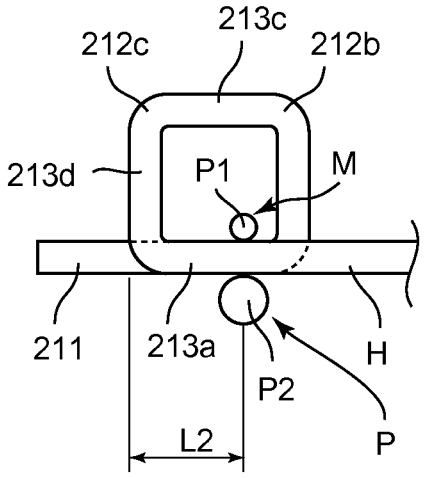


Fig.3B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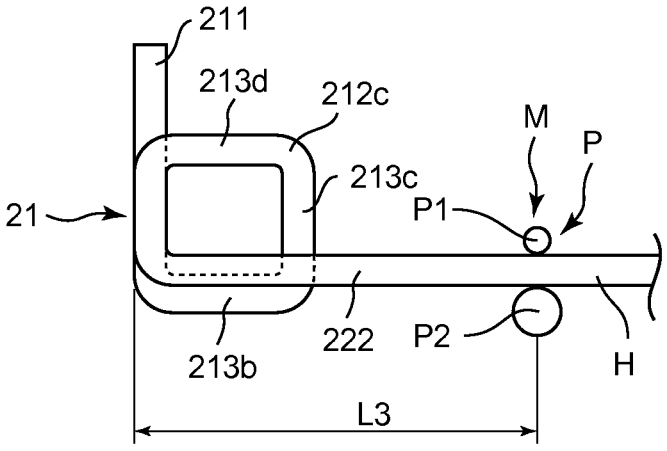
213d
P1
M
211
213a
H
P2
P
L2

Fig.4A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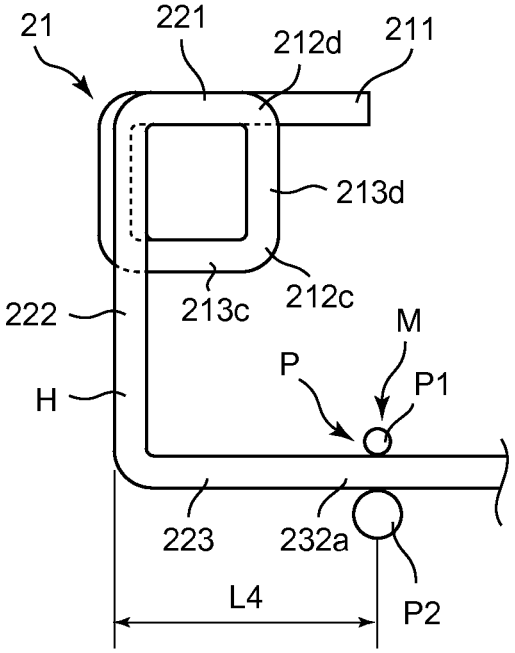
P
213c
21
P1
222
P2
H
213b
L3

Fig.4B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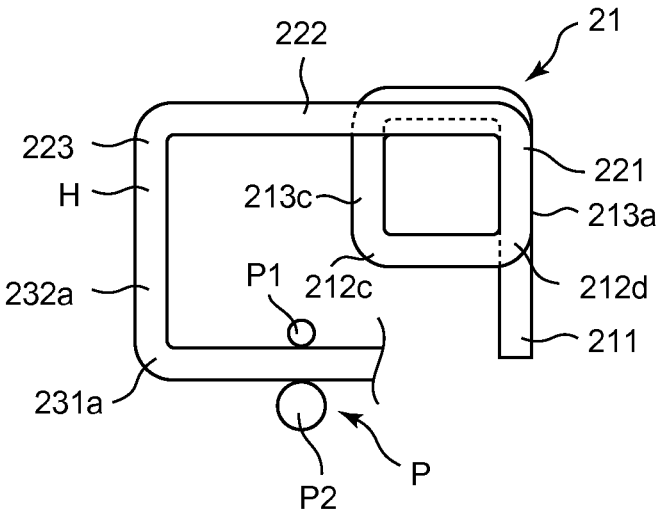
211
213d
213c
212c
222
M
P
P1
H
223
232a
L4
P2

Fig.5A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223
221
H
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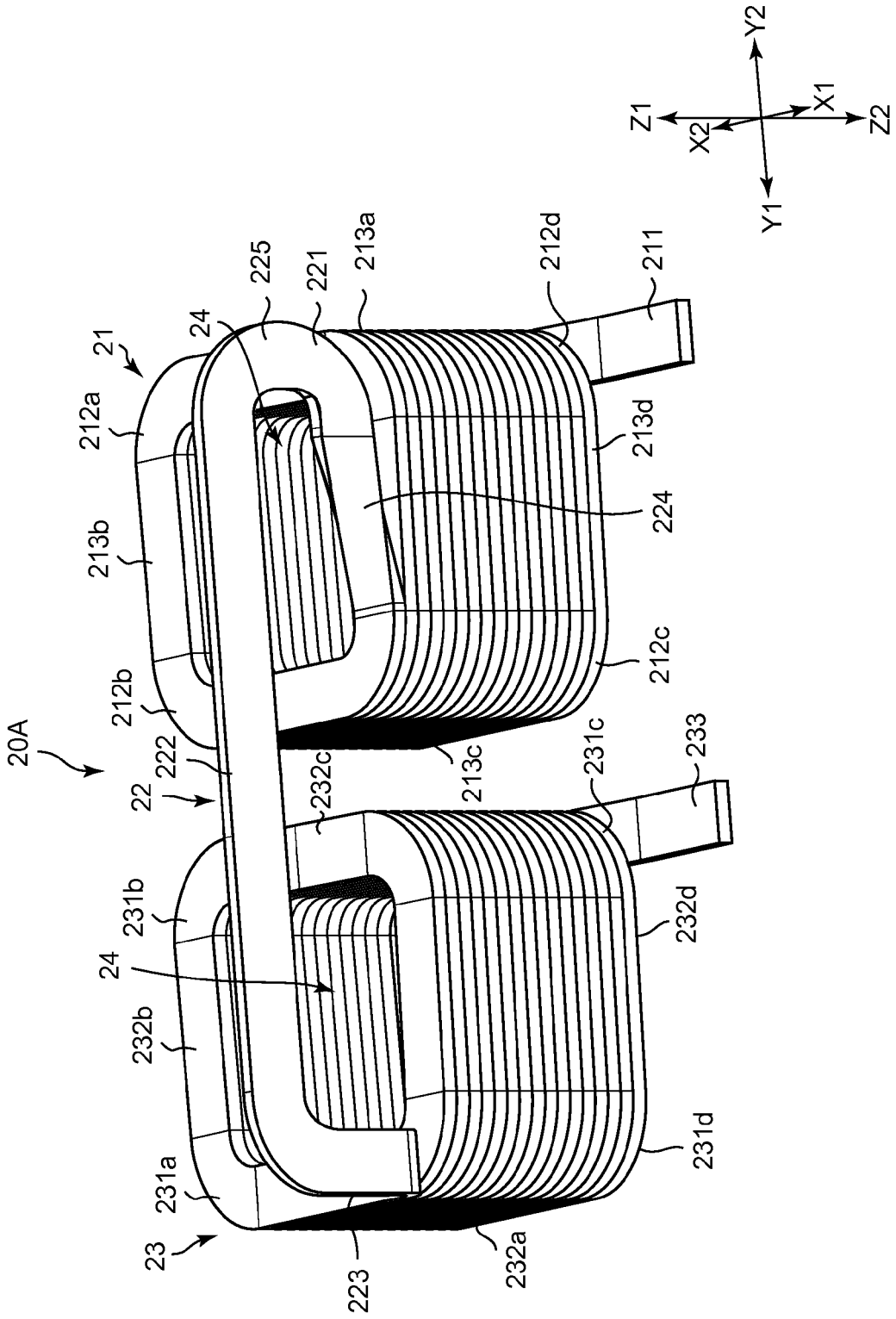
213a
P1
212c
212d
232a
211
231a
P
P2

Fig.5B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X2
Z2
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213b
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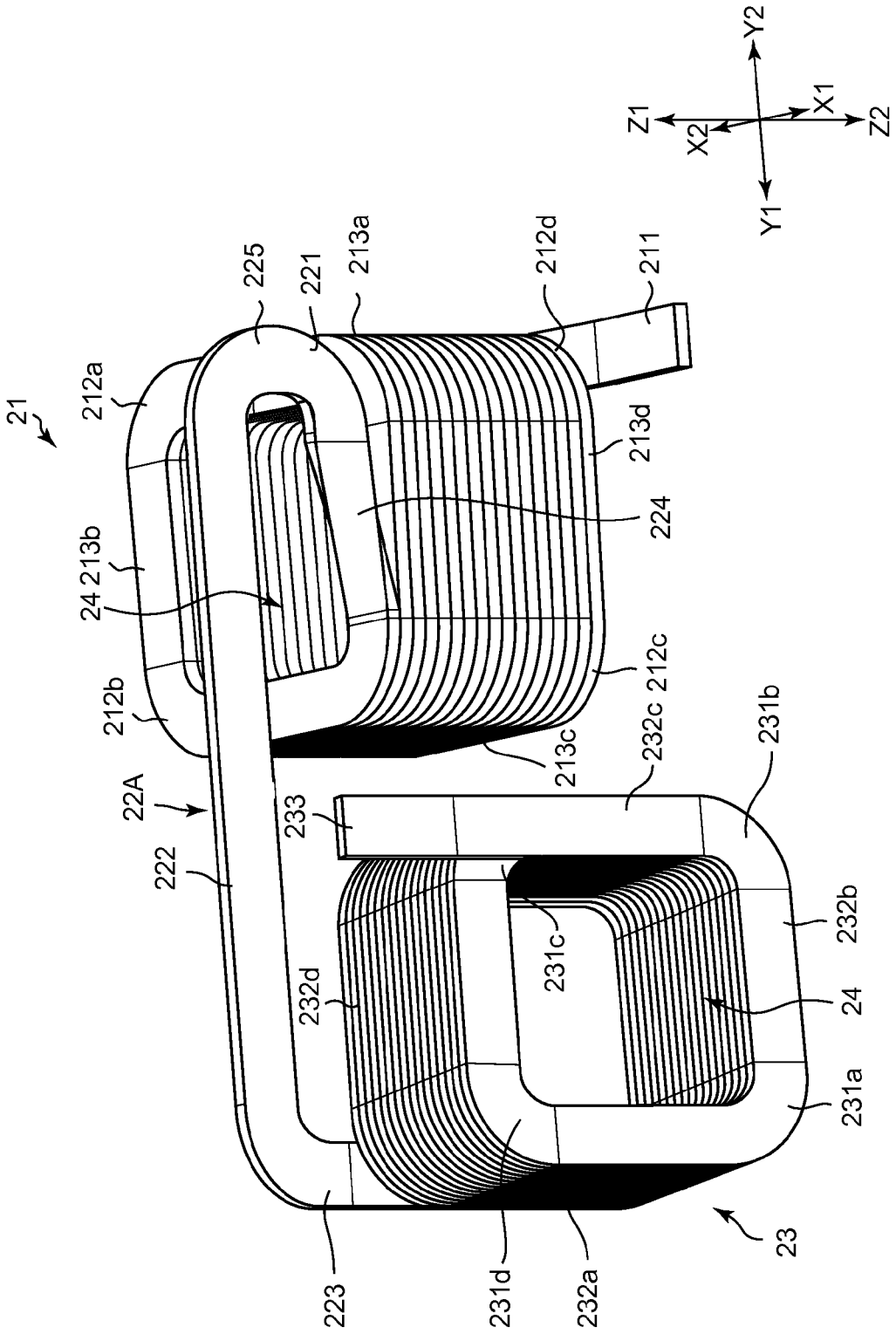
231d
232a
232b
232c
232d
233

Fig.6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X2
Z2
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213a
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213d
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213b
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212b
212c
213c
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22A
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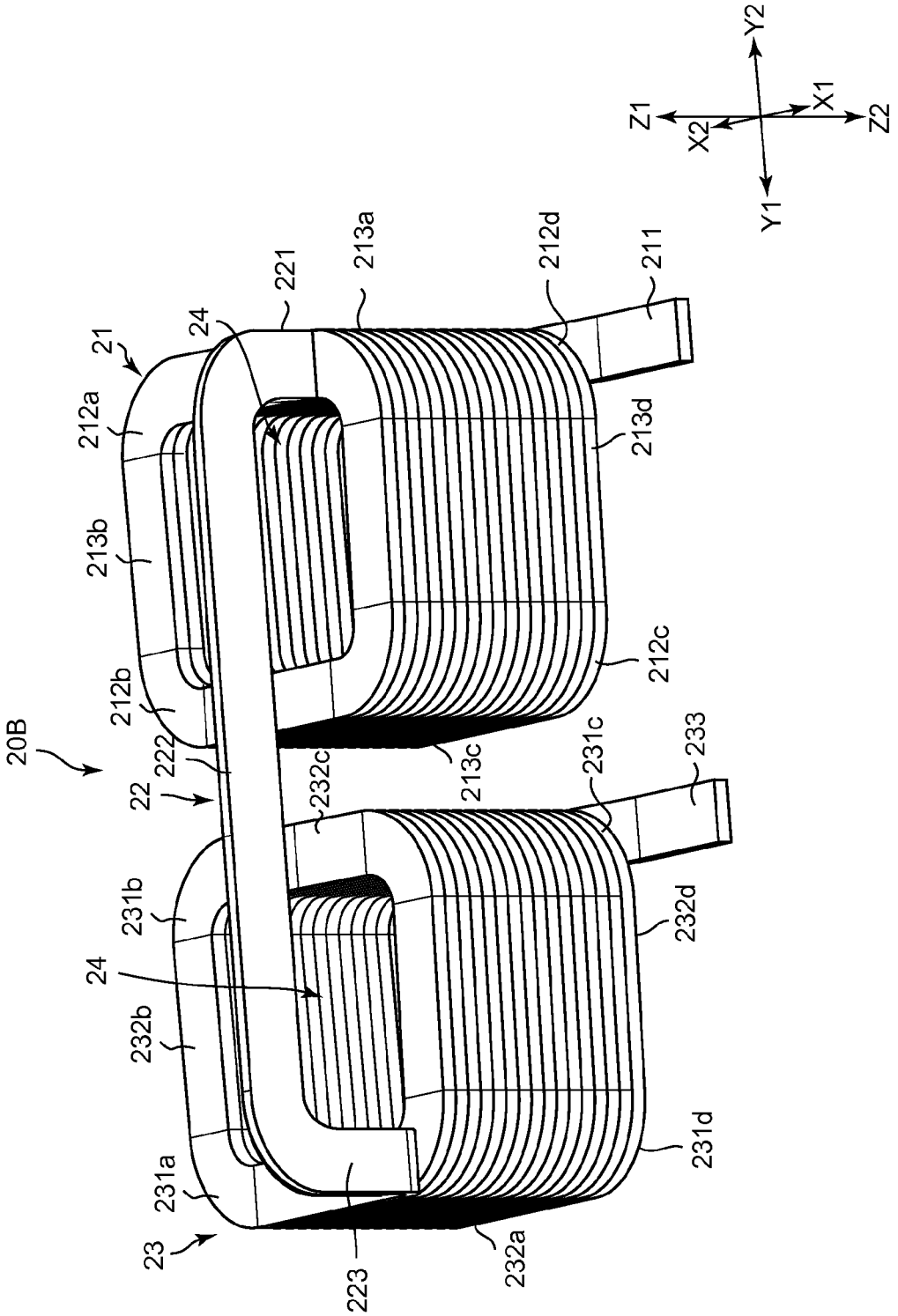
222
232b
231c
232d
24
231a
23
223
231d
232a

Fig.7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211
213d
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232c
231c
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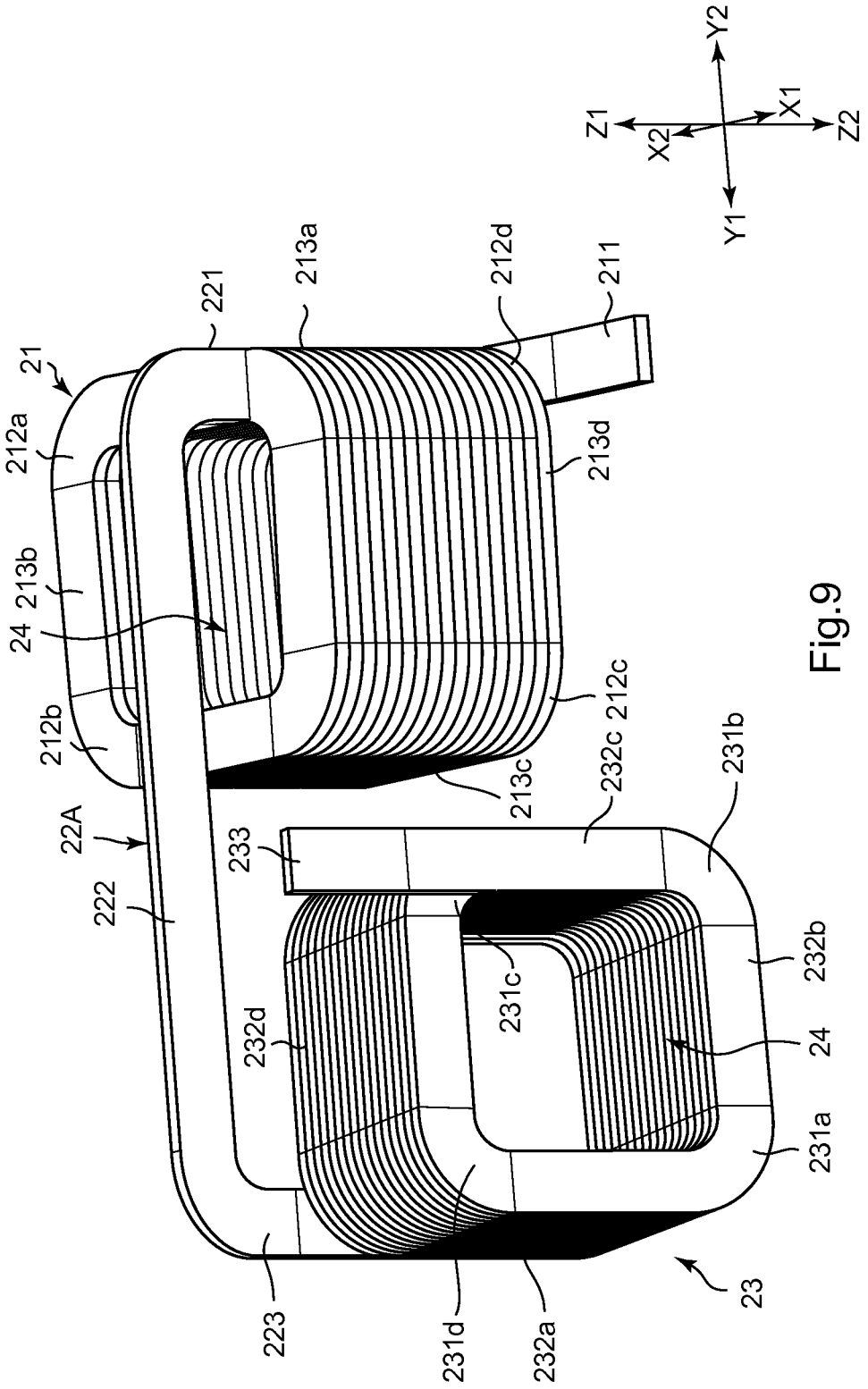
231b
24
232b
231a
23
223
232a
232d
231d

Fig.8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X2
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212c
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22A
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232b
231c
232d
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231a
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231d
232a
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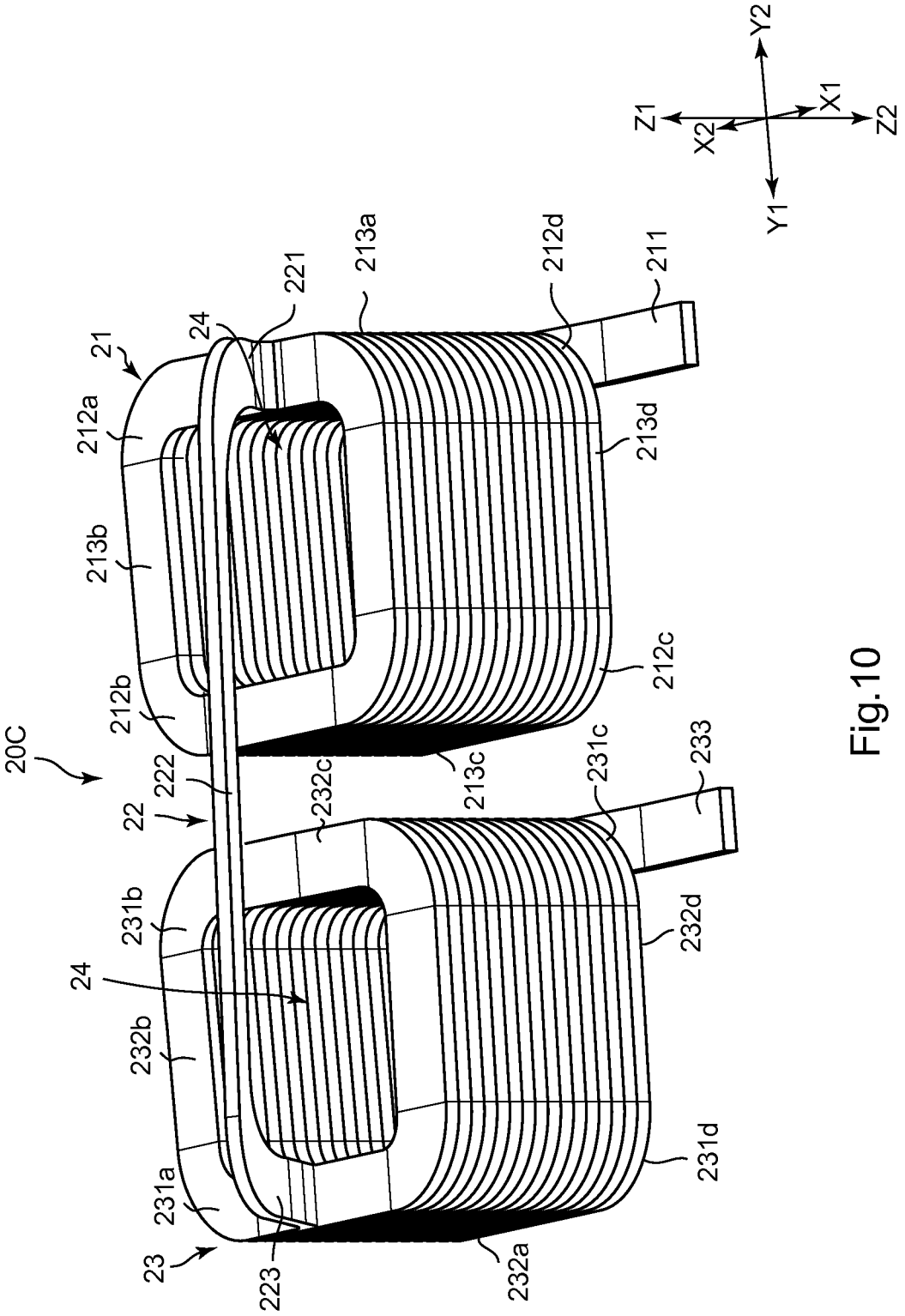
Fig.9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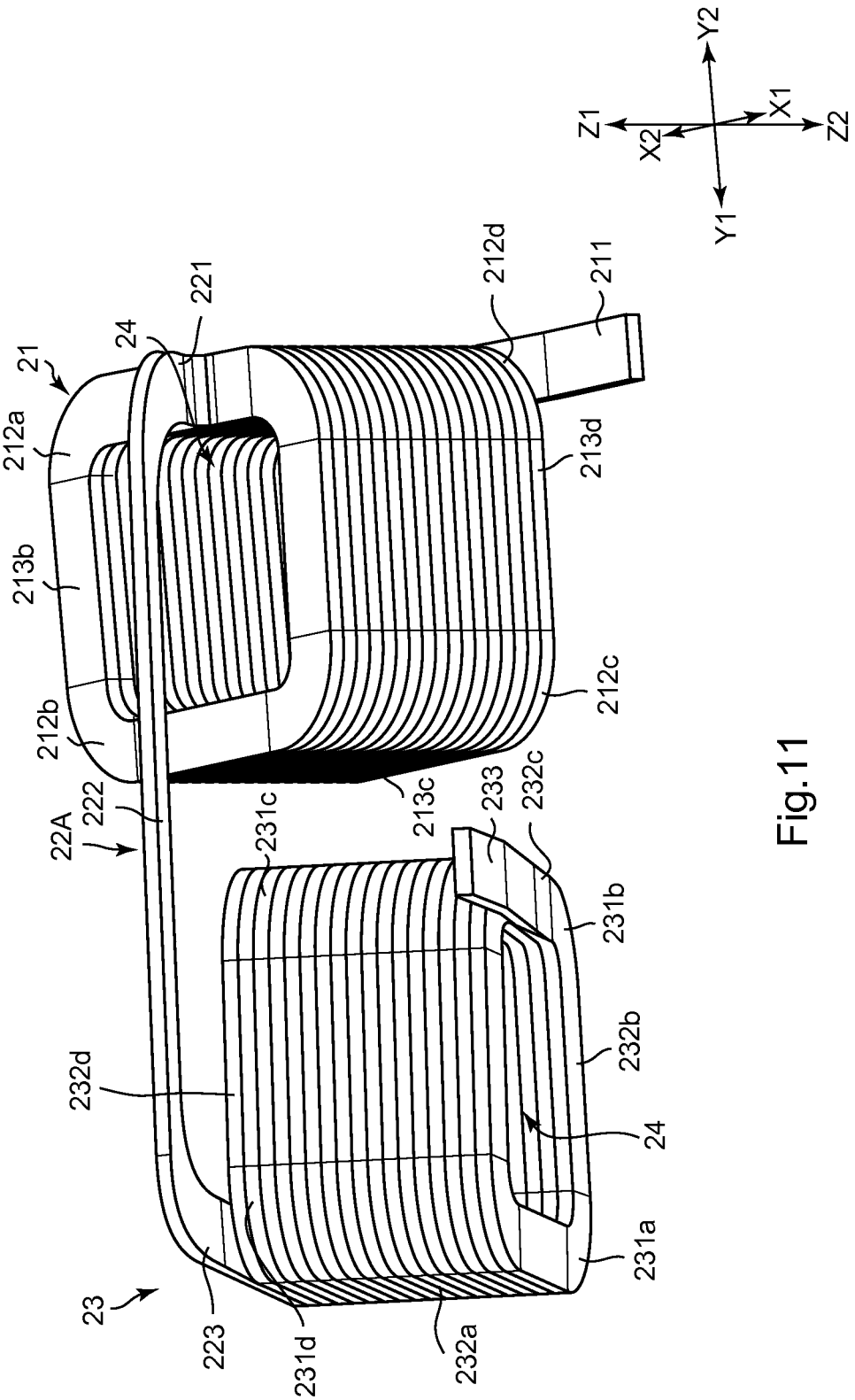
232b
232c
232d
233

Fig.10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231b
232d
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231a
23
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231d
232a

Fig.11

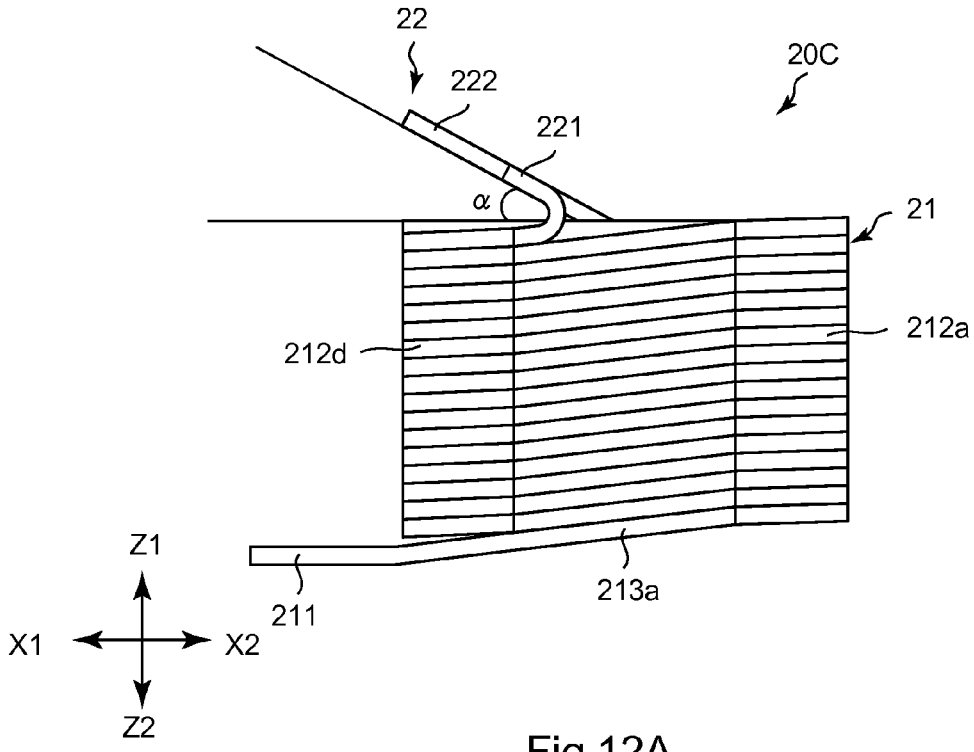


Fig.12A

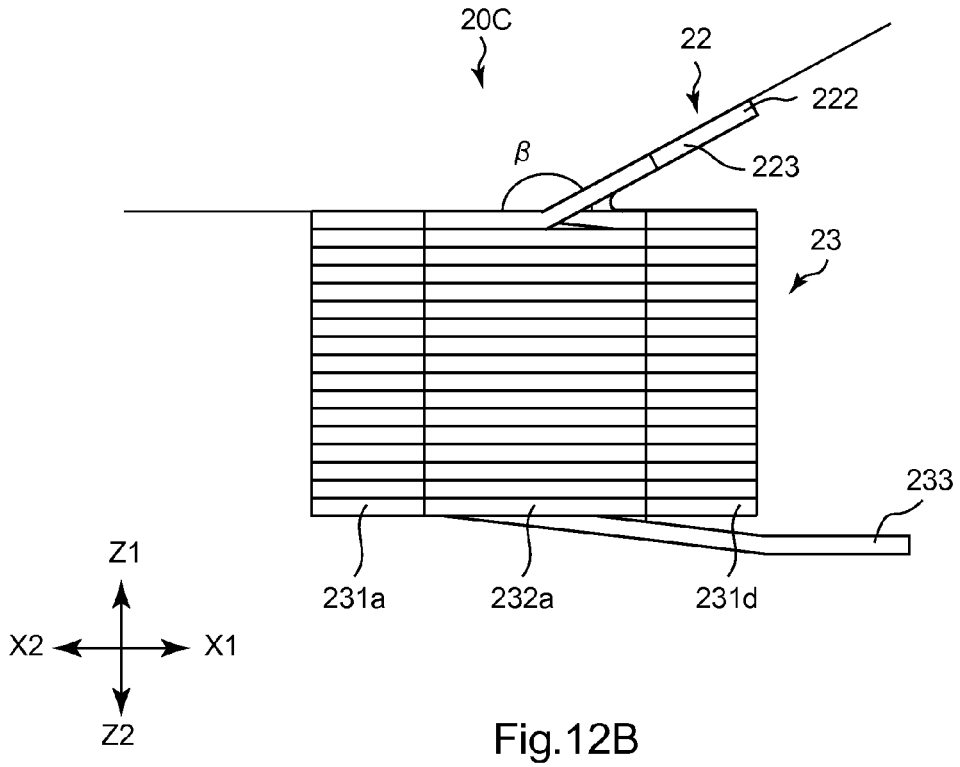
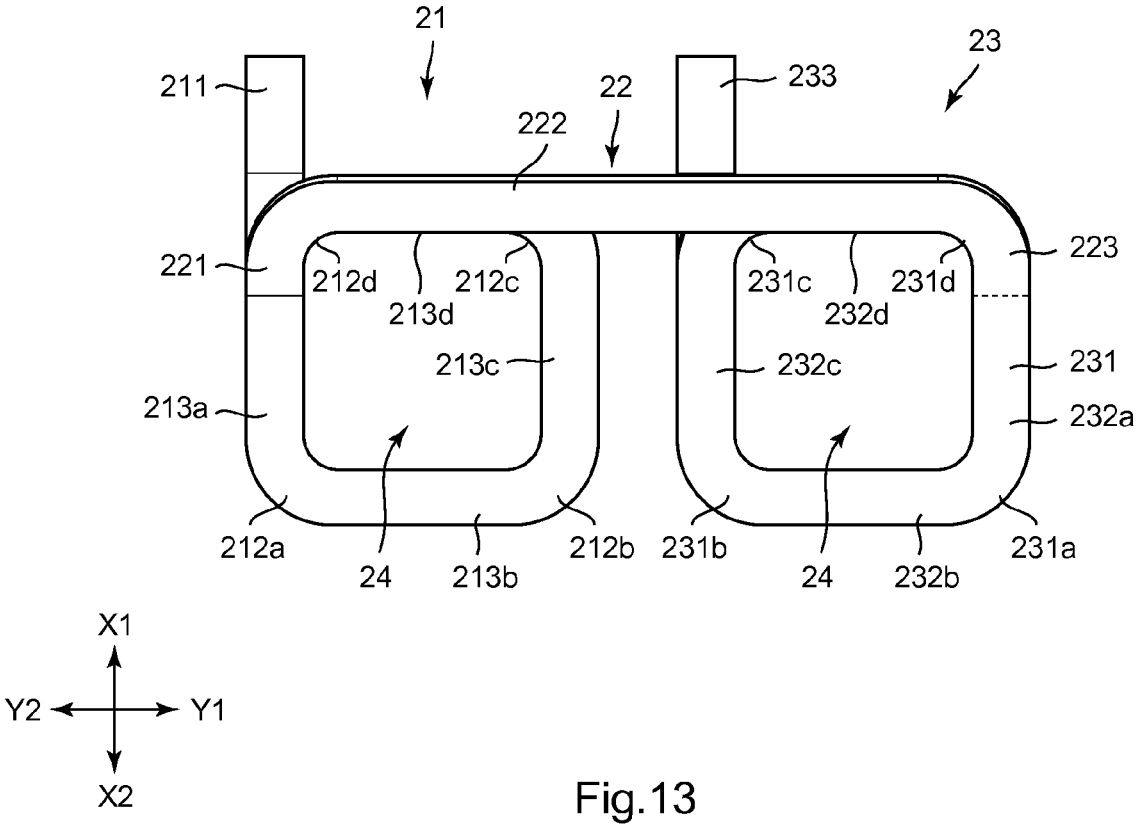


Fig.12B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X1
Y2
Y1
X2

Fig.13

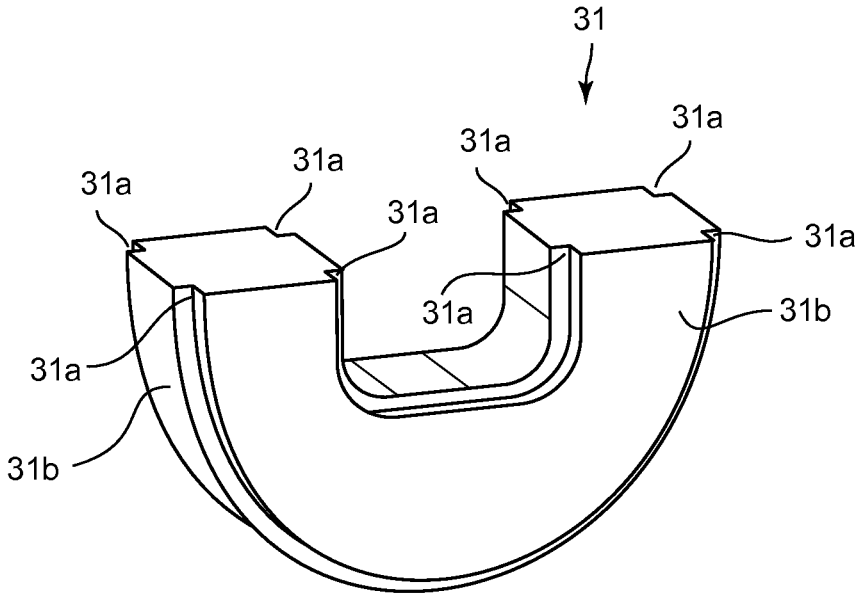
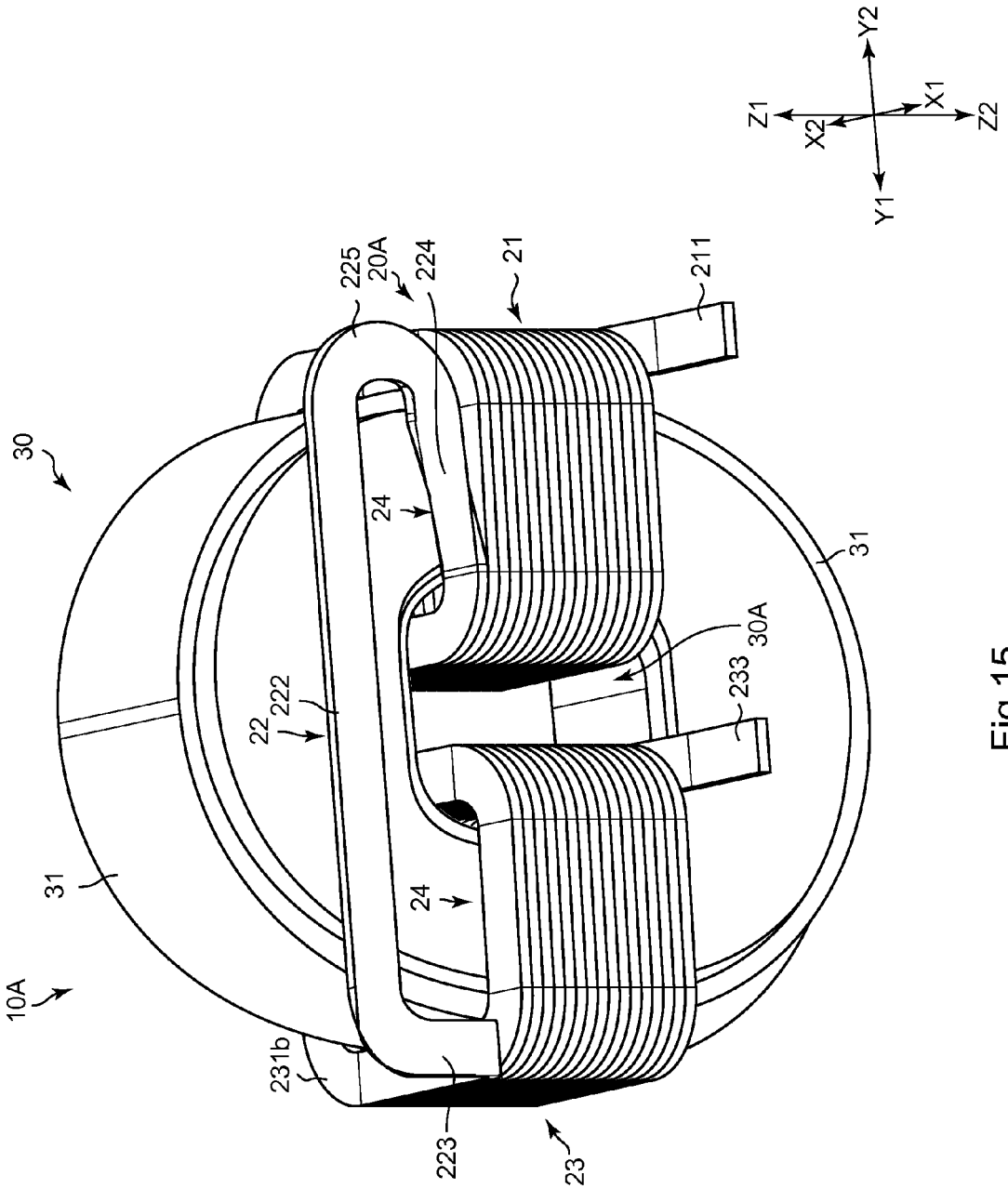


Fig.14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10A
231b
223
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Fig.15

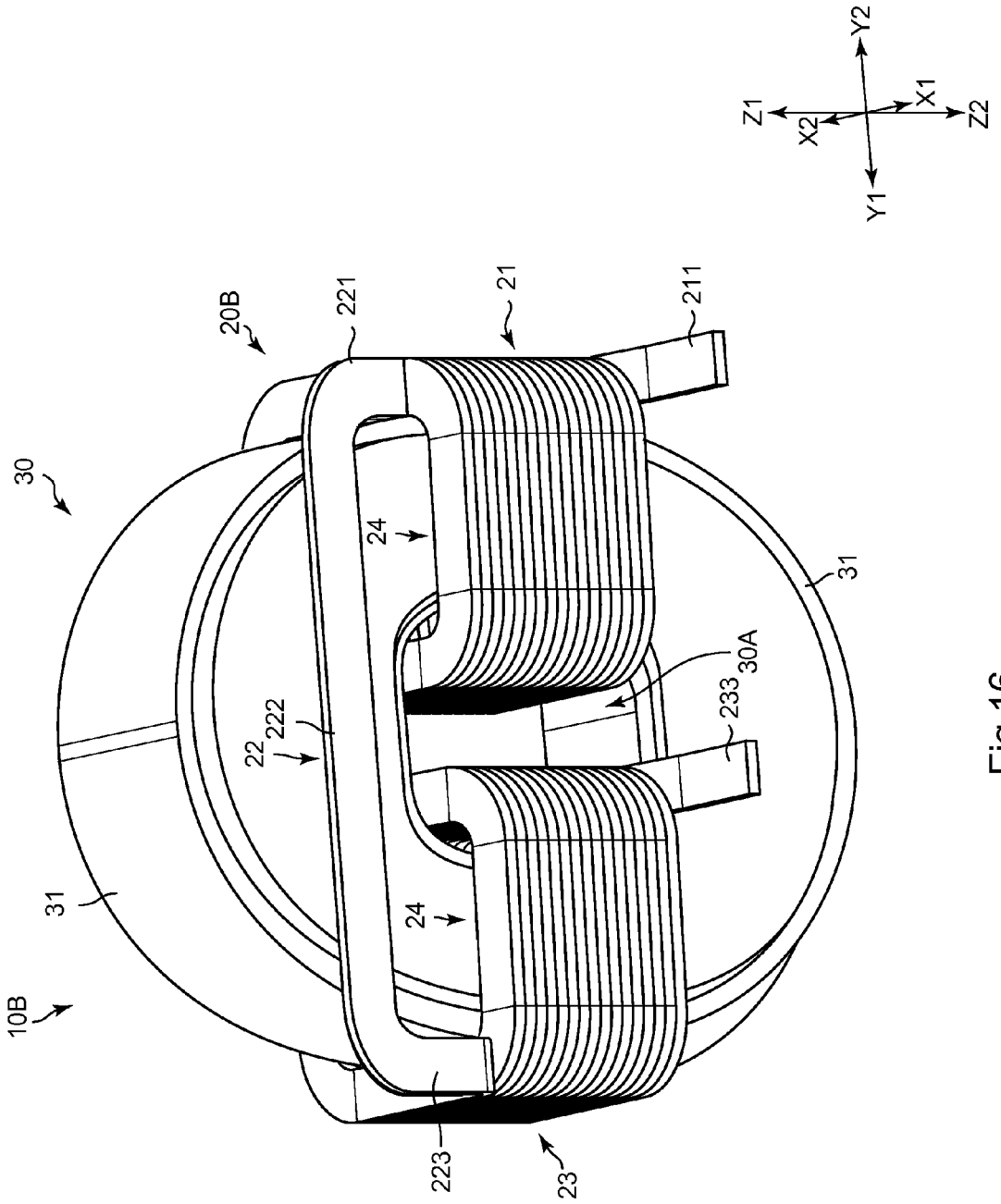
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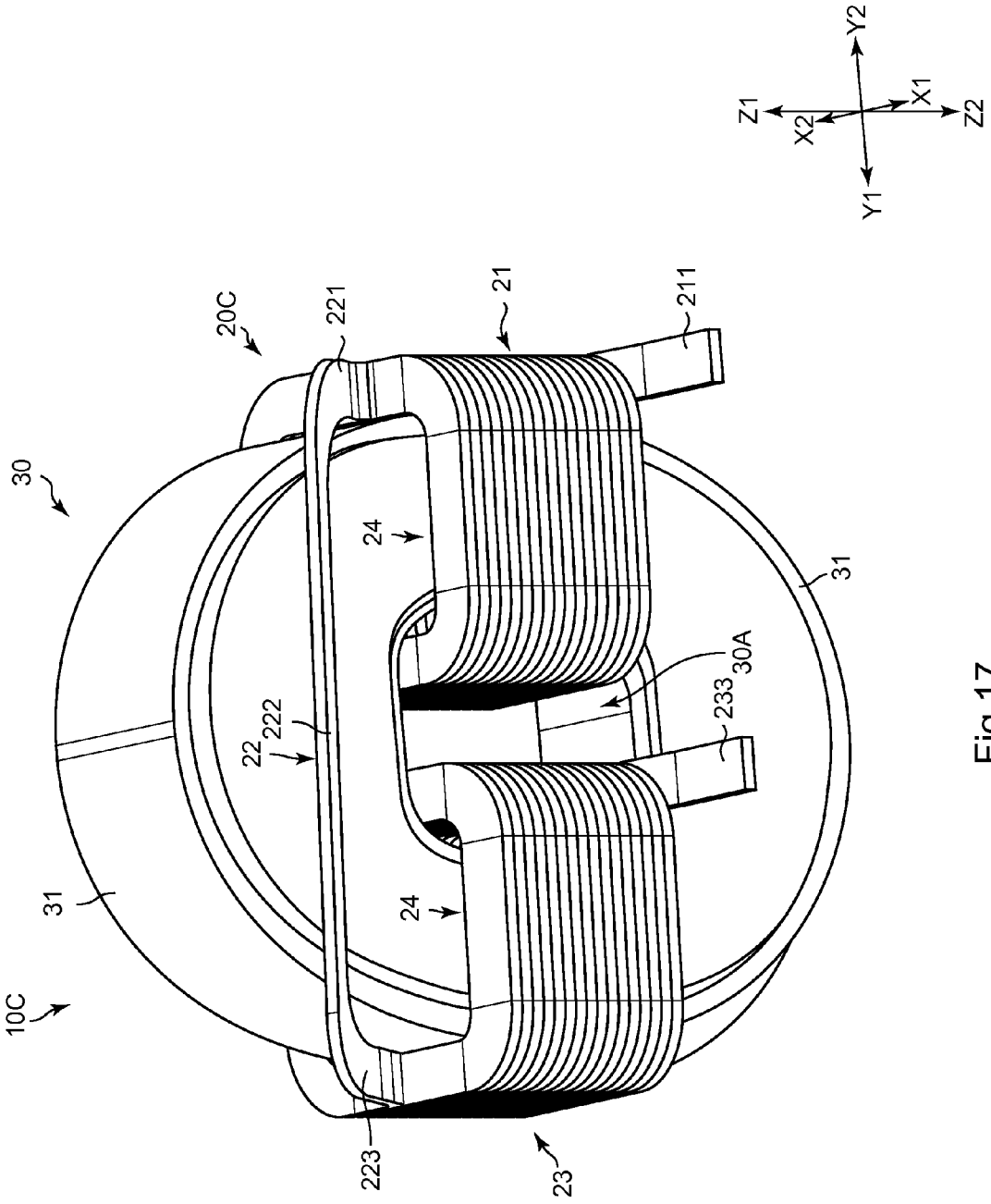
Fig.16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23

Fig.17

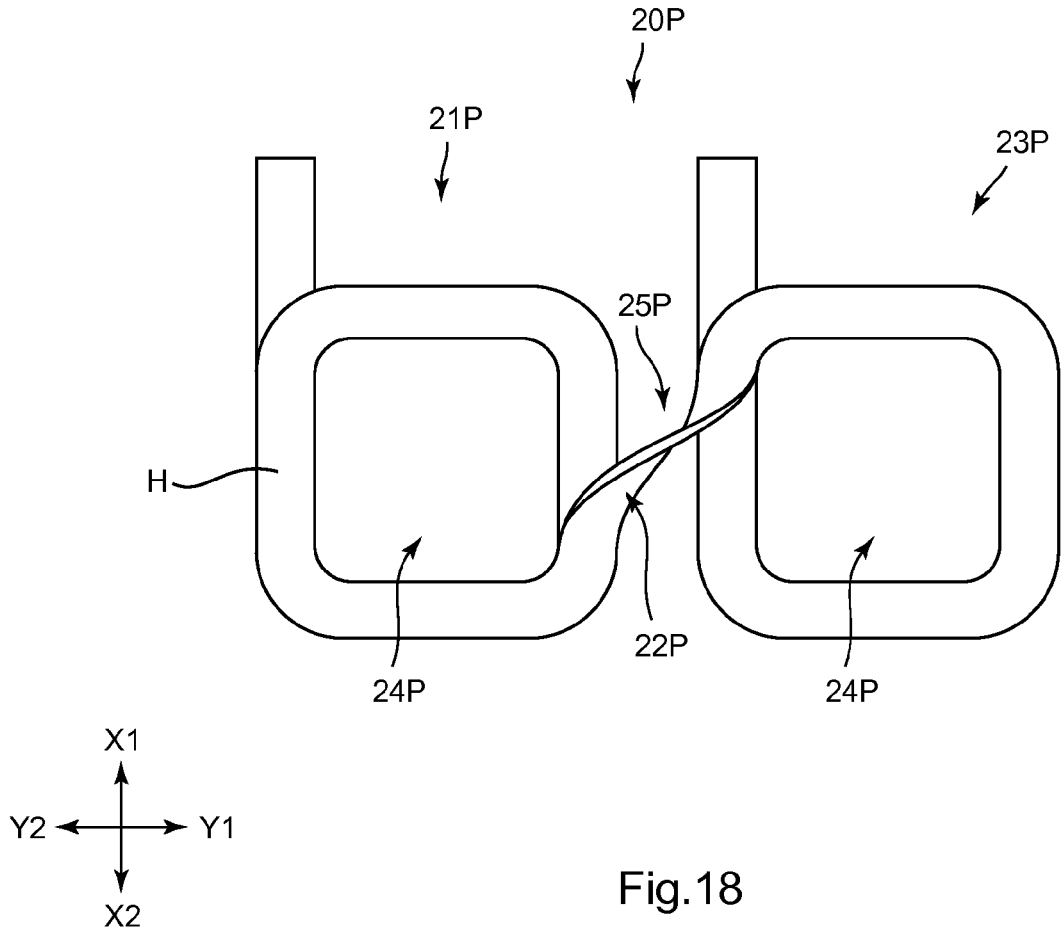

Fig.18

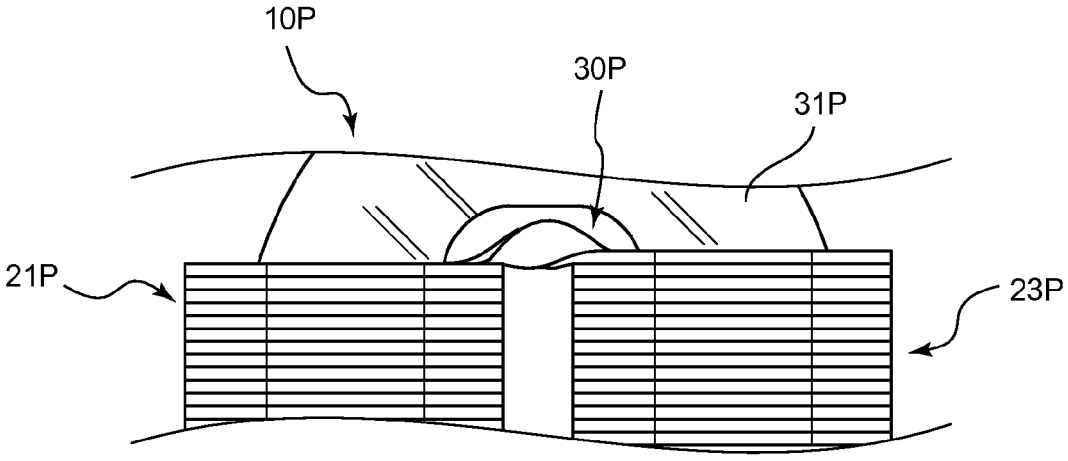

Fig.19

WINDING STRUCTURE, COIL WINDING, COIL PART, AND COIL WINDING MANUFACTURING METHOD

The present invention claims priority under 35 U.S.C. §119 to Japanese Application No. 2012-266622 filed Dec. 5, 2012, the entire content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a winding structure, a coil winding, a coil part, and a coil winding manufacturing method.

2. Description of the Related Art

In a drive unit for driving wheels of an automobile with a power generator which utilizes natural energy, a power supply device, and a motor, a coil part (reactor) is used in an electric circuit in order to improve power efficiency and remove noise. In such a coil part, for the purpose of corresponding to large electric current and improving a space factor, a flat wire is generally used. Patent Document 1 describes a coil part using such a flat wire.

[Patent Document 1] Japanese Patent No. 3398855 (see FIG. **4** to FIG. **6**)

SUMMARY OF THE INVENTION

In the structure of Patent Document 1, a twisted portion exists in a part (connecting wire part) between a first winding part (first coil part) and a second winding part (second coil part), and the winding parts are provided so that an electric current flowing through the flat wire is inverted between the first winding part and the second winding part by this twisted portion.

Here, FIG. **18** illustrates a plan view of a coil winding **20**P in which a twisted portion similar to that of Patent Document 1 exists. Further, FIG. **19** illustrates a partial side view of a coil part **10**P in which the twisted portion exists. When the twisted portion **25**P as illustrated in FIG. **18** exists, an extra space approximately equal to the width of a flat wire H is needed in an inside (ring hole **30**P) of a ring-shaped core **31**P, as illustrated in FIG. **19**. Dimensions of the coil part **10**P become large by that such an extra space is needed, which hinders miniaturization of the coil part **10**P.

The present invention is made in view of such problems, and it is an object thereof to provide a winding structure, a coil winding, a coil part, and a coil winding manufacturing method, which are capable of preventing occurrence of an extra space due to existence of a connecting wire part when a flat wire is processed to form two winding parts and a connecting wire part connecting the winding parts.

To solve the above-described problem, one aspect of a winding structure of the present invention has: a first winding part formed by winding a flat wire; a second winding part formed by winding the flat wire continuing to the first winding part, the second winding part being wound in a same winding direction as a winding direction of the first winding part; and a part to be connecting wire located between the first winding part and the second winding part to connect the winding parts, wherein the part to be connecting wire has: an interval defining portion defining an interval between the first winding part and the second winding part; a first coupling portion with one end side continuing to the interval defining portion by forming an edgewise bending and another end side continuing to the first winding part on one side in an axial direction of the first winding part; and a second coupling portion with one end side continuing to the interval defining portion by forming an edgewise bending and another end side continuing to the second winding part on another side in an axial direction of the second winding part.

Further, in another aspect of the winding structure of the present invention, in addition to the above-described invention, preferably, the first coupling portion is provided with: a planar extending portion continuing to the interval defining portion by forming an edgewise bending; and a portion for twisting which is located between the first winding part and the planar extending portion and becomes a twisted portion by twisting.

Moreover, in another aspect of the winding structure of the present invention, in addition to the above-described invention, preferably, a first terminal on a side opposite to the part to be connecting wire in the first winding part and a second terminal on a side opposite to the part to be connecting wire in the second winding part extend in opposite directions from each other toward respective front end sides thereof, and one of the first terminal and the second terminal is located on a facing portion side where the first winding part and the second winding part face each other, and the other of the first terminal and the second terminal is located on an outer peripheral side where the first winding part and the second winding part do not face each other.

Further, preferably, a coil winding which is another invention of the present invention uses the above-described winding structure, wherein a boundary portion between the first coupling portion and the first winding part is bent so that the first coupling portion extends in a direction to depart from the first winding part, a boundary portion between the second coupling portion and the second winding part is bent so that the second coupling portion extends in a direction to depart from the second winding part, and a connecting wire part is formed from the part to be connecting wire by the bending of the boundary portions.

Moreover, in another aspect of the coil winding of the present invention, in addition to the above-described invention, preferably, the boundary portion between the first coupling portion and the first winding part is bent so that an extending direction of the first coupling portion is provided in substantially parallel with an axial direction of the first winding part, and the boundary portion between the second coupling portion and the second winding part is bent so that an extending direction of the second coupling portion is provided in substantially parallel with an axial direction of the second winding part.

Further, in another aspect of the coil winding of the present invention, in addition to the above-described invention, preferably, the boundary portion between the first coupling portion and the first winding part is bent so that an extending direction of the first coupling portion is provided obliquely with respect to an axial direction of the first winding part, and the boundary portion between the second coupling portion and the second winding part is bent so that an extending direction of the second coupling portion is provided obliquely with respect to an axial direction of the second winding part.

Moreover, preferably, a coil winding which is another invention of the present invention uses the above-described winding structure, wherein the flat wire located in the portion for twisting is twisted to form a twisted portion in which a width direction of the flat wire extends in a direction to depart from the first winding part, and a boundary portion between the second coupling portion and the second winding part is bent so that the second coupling portion extends in a direction to depart from the second winding part.

Further, in another aspect of the coil winding of the present invention, in addition to the above-described invention, preferably, a first terminal on a side opposite to the connecting wire part in the first winding part and a second terminal on a side opposite to the connecting wire part in the second winding part extend in a same direction as each other toward respective front end sides thereof, and one of the first terminal and the second terminal is located on a facing portion side where the first winding part and the second winding part face each other, and the other of the first terminal and the second terminal is located on an outer peripheral side where the first winding part and the second winding part do not face each other.

Moreover, preferably, a coil part which is another invention of the present invention has the above-described coil winding and a core body formed from a magnetic material, provided in a ring shape, and inserted through a center hole of the first winding part and a center hole of the second winding part.

Further, preferably, a coil winding manufacturing method which is another invention of the present invention is a coil winding manufacturing method for forming a coil winding from a flat wire, the method including: a first winding step of winding the flat wire to form a first winding part; a part to be connecting wire forming step of forming a part to be connecting wire continuing to the first winding part; a second winding step of winding the flat wire in a same winding direction as a winding direction of the first winding part to form a second winding part continuing to the part to be connecting wire; and a connecting wire part forming step of forming a connecting wire part from the part to be connecting wire, wherein the part to be connecting wire forming step has: a first feeding step of feeding, after the first winding step and before the second winding step, the flat wire farther than a bending part to provide a first fed portion continuing to the first winding part; a first bending step of performing, at the bending part after the first feeding step, edgewise bending of the flat wire in the same direction as the winding direction of the first winding part to form a first coupling portion continuing to the first winding part; a second feeding step of feeding, after the first bending step, the flat wire to provide a second fed portion; a second bending step of performing, at the bending part after the second feeding step, edgewise bending of the flat wire in the same direction as the winding direction of the first winding part to form an interval defining portion continuing to the first coupling portion and defining an interval between the first winding part and the second winding part; and a third feeding step of feeding, after the second bending step, the flat wire farther than the bending part to provide a third fed portion continuing to the interval defining portion and the second winding part.

According to the present invention, it becomes possible to provide a winding structure, a coil winding, a coil part, and a coil winding manufacturing method, which are capable of preventing occurrence of an extra space due to existence of a connecting wire part when a flat wire is processed to form two winding parts and a connecting wire part connecting the winding parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view illustrating a shape of a winding structure according to one embodiment of the present invention;

FIG. **2** is a plan view illustrating the shape of the winding structure of FIG. **1**;

FIGS. **3**A and **3**B illustrate a manufacturing method of the winding structure, FIG. **3**A being a diagram illustrating a state that a flat wire before being bent is fed by a length L**1**, FIG. **3**B being a diagram illustrating a state that the flat wire fed by the length L**1** is bent;

FIGS. **4**A and **4**B illustrate the manufacturing method of the winding structure, FIG. **4**A being a diagram illustrating a state that the flat wire is fed by a length L**2** corresponding to a first coupling portion of a part to be connecting wire, FIG. **4**B being a diagram illustrating a state that the flat wire is fed by a length L**3** corresponding to an interval defining portion of a part to be connecting wire;

FIGS. **5**A and **5**B illustrate the manufacturing method of the winding structure, FIG. **5**A being a diagram illustrating a state that a length L**4** of the sum of a length corresponding to a second coupling portion and a straight portion of the second winding part is fed, FIG. **5**B being a diagram illustrating a state that the fed flat wire is bent;

FIG. **6** is a perspective view illustrating a shape of a coil winding formed from the winding structure of FIG. **1**;

FIG. **7** is a perspective view illustrating a middle stage when the coil winding illustrated in FIG. **6** is produced;

FIG. **8** is a perspective view illustrating a shape of a coil winding formed from the winding structure of FIG. **1** and is a view illustrating a type different from FIG. **6**;

FIG. **9** is a perspective view illustrating a middle stage when the coil winding illustrated in FIG. **8** is produced;

FIG. **10** is a perspective view illustrating a shape of a coil winding formed from the winding structure of FIG. **1** and illustrating a type different from FIG. **6** and FIG. **8**;

FIG. **11** is a perspective view illustrating a middle stage when the coil winding illustrated in FIG. **10** is produced;

FIGS. **12**A and **12**B are side views illustrating a bending state of the flat wire in the coil winding illustrated in FIG. **10**, FIG. **12**A being a diagram illustrating a bending angle of the first coupling portion, FIG. **12**B being a diagram illustrating a bending angle of the second coupling portion;

FIG. **13** is a is a plan view illustrating a shape of the coil winding of FIG. **10**;

FIG. **14** is a perspective view illustrating a shape of a core constituting a coil part;

FIG. **15** is a perspective view illustrating a coil part produced using the coil winding illustrated in FIG. **6**;

FIG. **16** is a perspective view illustrating a coil part produced using the coil winding illustrated in FIG. **8**;

FIG. **17** is a perspective view illustrating a coil part produced using the coil winding illustrated in FIG. **10**;

FIG. **18** is a plan view illustrating a structure of a conventional coil winding and illustrating a state that a twisted portion exists in a connecting wire part; and

FIG. **19** is a partial side view illustrating the structure of the conventional coil part and is a view illustrating a structure in the vicinity of the twisted portion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, a coil part **10** (coil parts **10**A to **10**C; see FIG. **15** to FIG. **17**) according to one embodiment of the present invention will be described based on the drawings. Note that in the following description, manufacturing processes are described together when a coil winding **20** (coil windings **20**A to **20**C; see FIG. **6**, FIG. **8**, and FIG. **10**) of a coil part **10** is described.

Note that in the following description, an axial direction of the coil winding **20** and a winding structure **200** is denoted as Z direction, a side facing toward a terminal portion **233** (which will be described later) from a terminal portion **211** (which will be described later) in the Z direction is denoted as

Z1 side, and an opposite side thereof is denoted as Z2 side. Further, a direction in which the terminal portion **233** and the terminal portion **211** extend is denoted as X direction, a side where the terminal portion **211** projects (see FIG. **2** and the like) with respect to a first winding part **21** (which will be described later) is denoted as X1 side, and the opposite side thereof (see FIG. **1** and the like; a side where the terminal portion **233** projects) is denoted as X2 side. Further, a direction orthogonal to the X direction and the Z direction is denoted as Y direction, a side where a second winding part **23** is located with respect to the first winding part **21** is denoted as Y1 side, and the opposite side thereof is denoted as Y2 side.

Further, in the following description, when it is unnecessary to distinguish the coil parts **10**A to **10**C from each other, they are referred to as a coil part **10**. Also when it is unnecessary to distinguish coil windings **20**A to **20**C from each other, they are referred to as a coil winding **20**.

<Regarding Formation of a Winding Structure **200**>

First, formation of a winding structure **200** during manufacturing of the coil winding **20** will be described.

FIG. **1** is a perspective view illustrating the winding structure **200**. FIG. **2** is a plan view illustrating the winding structure **200**. This winding structure **200** has a first winding part **21**, a part to be connecting wire **22**A, and a second winding part **23**.

When the winding structure **200** as illustrated in FIG. **1** and FIG. **2** is formed, first, a flat wire H is pulled off a supply source where the flat wire H is wound, such as a bobbin or reel, and the flat wire H is set to a bending machine (omitted from the illustrations). Thereafter, as illustrated in FIG. **3**A, a feeding unit (omitted from the illustrations) of the bending machine is activated to feed the flat wire H by a predetermined length L**1**.

At this time, the flat wire H is fed by a length L**1** of the sum of the terminal portion **211** and a straight portion **213***a* in the first winding part **21** of FIG. **1**, which will be described later, and by this feeding, a portion corresponding to a bent portion **212***a* in FIG. **1** is located at a bending part M of the bending machine illustrated in FIG. **3**A. At the bending part M, an inner jig P**1** and an outer jig P**2** are disposed, which constitute a processing unit P of the bending machine. The inner jig P**1** is disposed on an inner peripheral side when bending of the flat wire H is performed, and the outer jig P**2** is disposed on an outer peripheral side when bending of the flat wire H is performed.

When the processing unit P of the bending machine is then activated, as illustrated in FIG. **3**B, bending of the flat wire H is performed so that the flat wire H follows an outer peripheral surface of the inner jig P**1**. In this bending, a longitudinal (extending) direction and a width direction of the flat wire H are bent by approximately 90 degrees, but a thickness direction of the flat wire H is in a barely changed (bent) state. By this bending, the terminal portion **211** (corresponding to a first terminal) and the straight portion **213***a* in the first winding part **21** illustrated in FIG. **1** and FIG. **2** are formed in an integrated state. Note that in the following description, "approximately 90 degrees" include just 90 degrees or an angle equivalent to 90 degrees.

Thereafter, feeding of the flat wire H by actuation of the feeding unit of the bending machine and bending by actuation of the processing unit P of the bending machine are performed sequentially in a similar manner Thus, the first winding part **21** is formed which is wound in a rectangular shape (what is called an edgewise winding) and has four bent portions **212***a* to **212***d* and four straight portions **213***a* to **213***d*.

After the first winding part **21** is formed, the feeding unit of the bending machine is actuated to feed the flat wire H by a length L**2** corresponding to a first coupling portion **221** of the part to be connecting wire **22**A as illustrated in FIG. **4**A. In the structure illustrated in FIG. **4**A, the flat wire H is fed by the length L**2** corresponding to the first coupling portion **221** so that it continues to the bent portion **212***d* (corresponding to a first feeding step; note that this fed portion corresponds to a first fed portion) and the end of the fed portion is positioned at the bending part M. Thereafter, the processing unit P of the bending machine is actuated to bend the flat wire H in the same winding direction as the winding direction of the first winding part **21** (corresponding to a first bending step). Thus, the first coupling portion **221** continuing to the first winding part **21** is formed.

Further, after the first coupling portion **221** is formed, the feeding unit of the bending machine is actuated to feed the flat wire H by a length L**3** corresponding to an interval defining portion **222**, as illustrated in FIG. **4**B (corresponding to a second feeding step; note that this fed portion corresponds to a second fed portion). Then, the end of the fed portion is positioned at the bending part M. Thereafter, the processing unit P of the bending machine is actuated to bend the flat wire H in the same winding direction as the winding direction of the first winding part **21** (corresponding to a second bending step). Thus, the interval defining portion **222** continuing to the first coupling portion **221** is formed.

Next, after the interval defining portion **222** is formed, as illustrated in FIG. **5**A, the feeding unit of the bending machine is actuated to feed a length L**4** of the sum of a length corresponding to a second coupling portion **223** (the length of the second coupling portion **223** is equal to that of the first coupling portion **221**) and a straight portion **232***a* of the second winding part **23** (corresponding to a third feeding step; note that this fed portion corresponds to a third fed portion), and a portion corresponding to a bent portion **231***a* of the second winding part **23** is positioned at the bending part M of the bending machine. Then, the processing unit of the bending machine is actuated to bend the flat wire H in the same winding direction as the winding direction of the first winding part **21** (corresponding to a second bending step). Thus, as illustrated in FIG. **5**B, the second coupling portion **223** and the straight portion **232***a* are formed in an integrated state.

Note that the first coupling portion **221**, the interval defining portion **222**, and the second coupling portion **223** constitute the part to be connecting wire **22**A connecting the first winding part **21** and the second winding part **23**. The part to be connecting wire **22**A is a part which becomes a connecting wire part **22** by undergoing bending, or bending and twisting, as will be described later.

Thereafter, feeding of the flat wire H by actuation of the feeding unit of the bending machine and bending by actuation of the processing unit of the bending machine are performed sequentially in a manner similar to the formation of the first winding part **21**. Thus, the second winding part **23** is formed which is wound in a rectangular shape (what is called an edgewise winding) and has four bent portions **231***a* to **231***d* and four straight portions **232***a* to **232***d*.

Note that when the last bending of the second winding part **23** is performed, the terminal portion **233** (corresponding to a second terminal) and the straight portion **232***c* in the second winding part **23** are formed in an integrated state. Thus, the winding structure **200** as illustrated in FIG. **1** and FIG. **2** is formed.

<Regarding Formation of the Coil Winding **20**>

Next, formation of the coil winding **20** (coil windings **20**A to **20**C) will be described. When the coil winding **20** is formed from the winding structure **200**, a coil winding **20**A as illus-

trated in FIG. **6**, a coil winding **20**B as illustrated in FIG. **8**, and a coil winding **20**C as illustrated in FIG. **10** are formed.

(Regarding Formation of the Coil Winding **20**A of the Type Illustrated in FIG. **6**)

First, the case of forming the coil winding **20**A of the type illustrated in FIG. **6** will be described. In the following description, in the winding structure **200** illustrated in FIG. **1**, it is assumed that a portion for twisting **224**A is provided on a winding end side of the first winding part **21**. This portion for twisting **224**A is a component of the first coupling portion **221**, and in FIG. **1**, the portion for twisting **224**A and a planar extending portion **225** are provided in the first coupling portion **221**. When the coil winding **20**A as illustrated in FIG. **6** is formed, as illustrated in FIG. **7**, the portion for twisting **224**A is twisted by approximately 90 degrees. In the structure illustrated in FIG. **7**, the portion for twisting **224**A is twisted so that the face (surface) of a side on which the flat wire H is not to be stacked faces toward an outer peripheral side of the first winding part **21** as it proceeds from the first winding part **21** to the planar extending portion **225**.

By twisting such a portion for twisting **224**A, a twisted portion **224** is formed. Then, by forming this twisted portion **224**, the connecting wire part **22** formed from the part to be connecting wire **22**A is provided in a state of standing up with respect to the first winding part **21**.

Further, as illustrated in FIG. **6**, before or after the formation of the twisted portion **224**, a boundary portion between the second coupling portion **223** and the second winding part **23** is bent by approximately 90 degrees. The direction of this bending is such that a direction in which the second coupling portion **223** extends moves toward and away from the second winding part **23**.

Note that when the boundary portion between the second coupling portion **223** and the second winding part **23** is bent, they may be bent by approximately 90 degrees with respect to the flat wire H constituting the second winding part **23**. However, a front surface and a rear surface of the flat wire H constituting the second winding part **23** are not in parallel with the XY plane, but form an angle corresponding to the amount of thickness of the flat wire H on the XY plane. Accordingly, the above-described bending of the boundary portions by approximately 90 degrees may be bending so as to form approximately 90 degrees with respect to the XY plane. This point will be the same in the case of bending a boundary portion between the first coupling portion **221** and the first winding part **21** and the case of bending the boundary portion between the second coupling portion **223** and the second winding part **23** in FIG. **8** to FIG. **11**, as will be described later.

By bending as described above, the coil winding **20** as illustrated in FIG. **6** is formed.

(Regarding Formation of the Coil Winding **20**B Illustrated in FIG. **8**)

Next, the case of forming the coil winding **20**B as illustrated in FIG. **8** will be described. In the following description, it is assumed that the portion for twisting **224**A as described above is not provided on the winding end side of the first winding part **21** in the winding structure **200** illustrated in FIG. **1**.

When the coil winding **20**B as illustrated in FIG. **8** is formed, the boundary portion between the first coupling portion **221** and the first winding part **21** of the winding structure **200** illustrated in FIG. **1** is bent by approximately 90 degrees. This state is illustrated in FIG. **9**. The direction of this bending is a direction in which the first coupling portion **221** moves toward and away from the first winding part **21**. Further, before or after bending of the boundary portion between the first coupling portion **221** and the first winding part **21**, the boundary portion between the second coupling portion **223** and the second winding part **23** is bent by approximately 90 degrees. The direction of this bending is also a direction in which the second coupling portion **223** moves toward and away from the second winding part **23**.

By performing bending as described above, the coil winding **20**B as illustrated in FIG. **8** is formed.

(Regarding Formation of the Coil Winding **20**C Illustrated in FIG. **10**)

Next, the case of forming the coil winding **20**C as illustrated in FIG. **10** will be described. Note that also in the coil winding **20**C illustrated in FIG. **10**, it is assumed that the portion for twisting **224**A as described above is not provided on the winding end side of the first winding part **21**.

When the coil winding **20**C as illustrated in FIG. **10** is formed, as illustrated in FIG. **11**, the boundary portion between the first coupling portion **221** and the first winding part **21** is bent larger than 90 degrees. By this bending, on a side where the first coupling portion **221** continues to the first winding part **21**, an angle formed between the XY plane perpendicular to the axial direction (Z direction) and the first coupling portion **221** is an acute angle α as illustrated in FIG. **12**A.

Further, before or after bending of the boundary portion between the first coupling portion **221** and the first winding part **21**, the boundary portion between the second coupling portion **223** and the second winding part **23** is bent. The angle of bending at this time is an acute angle which does not exceed 90 degrees. By this bending, on a side where the second coupling portion **223** continues to the second winding part **23**, an angle formed between the XY plane perpendicular to the axial direction (Z direction) and the second coupling portion **223** is an obtuse angle β as illustrated in FIG. **12**B. Note that in general, the obtuse angle β is a value obtained by subtracting the acute angle α from 180 degrees.

By bending the boundary portions as described above, the connecting wire part **22** is formed from the part to be connecting wire **22**A. In this case, as illustrated in FIG. **10**, the connecting wire part **22** is provided in an inclined state with respect to the axial direction (Z direction) as compared to the case illustrated in FIG. **8**. Thus, when the coil winding **20**C is seen in a plan view as illustrated in FIG. **13**, it is possible to prevent the connecting wire part **22** from projecting largely toward the X1 side farther than the first winding part **21** and the second winding part **23**.

<Regarding Formation of the Coil Part **10** Using the Coil Winding **20**>

When the coil part **10** is formed using the coil winding **20** (coil windings **20**A to **20**C) as above, a core **31** as illustrated in FIG. **14** is formed separately from formation of the coil winding **20**. The core **31** has a U-shape when seen in a side view (what is called a cut core), and a ring-shaped core body **30** (see FIG. **15** to FIG. **17**) is formed by butting two such cores **31** having a U-shape. Note that in the following, a hole located on a center side of the ring-shaped core body **30** will be referred to as a ring hole **30**A.

The core **31** is formed from a magnetic material, and such a magnetic material may be a stack of silicon steel plates as well as a metal magnetic material such as iron-based material, permalloy, sendust, amorphous metal, or the like, or an oxide magnetic material. However, a mixture of these magnetic materials may be used, or a composite material of these magnetic materials may be used.

As illustrated in FIG. **14**, in this embodiment, the core **31** is provided to have the following cross-sectional shape. Specifically, it is provided to have a shape in which cutout parts **31***a* exist by cutting out four corners of a rectangle by a small

rectangle. Existence of such cutout parts **31***a* enables to prevent interference of the bent portions **212***a* to **212***d* of the first winding part **21** and the bent portions **231***a* to **231***d* of the second winding part **23** with the core **31**.

Before butting the two cores **31** as above, the coil winding **20** is retained on one core **31**. At this time, leg portions **31***b* of the core **31** are in a state of being inserted into respective center holes **24** of the first winding part **21** and the second winding part **23** of the coil winding **20**.

Thereafter, the other core **31** of the two cores **31** is butted against the one core **31**. At this time, leg portions **31***b* of the other core **31** are in a state of being inserted into the respective center holes **24** of the first winding part **21** and the second winding part **23**.

Then, the butted state of the one core **31** and the other core **31** is maintained. To maintain such a butted state, for example, an adhesive may be used to join butting faces of the cores **31** together, or the butted state of the cores **31** with each other may be maintained by any other joining means.

As described above, coil parts **10** as illustrated in FIG. **15** to FIG. **17** are produced. Note that the coil part **10**A illustrated in FIG. **15** is one using the coil winding **20**A illustrated in FIG. **6**, the coil part **10**B illustrated in FIG. **16** is one using the coil winding **20**B illustrated in FIG. **8**, and the coil part **10**C illustrated in FIG. **17** is one using the coil winding **20**C illustrated in FIG. **10**.

<Effects>

The winding structure **200**, the coil winding **20**, and the coil part **10** structured as above, and the manufacturing method of the coil winding **20** make it possible to prevent, when the connecting wire part **22** exists, enlargement of the ring hole **30**A of the core body **30** due to the existence of the connecting wire part **22**. That is, when the twisted portion **25**P exists in a connecting wire part **22**P connecting a first winding part **21**P and a second winding part **23**P as in the conventional coil winding **20**P illustrated in FIG. **18**, dimensions of the ring hole **30**P become large so as to accommodate the twisted portion **25**P as illustrated in FIG. **19**. In this case, the largest length in the Z direction of the twisted portion **25**P is approximately the same as the width of the flat wire H. Accordingly, an extra space is needed in the ring hole **30**P, and the coil part **10**P as the whole becomes large by the amount of the space.

However, the above-described coil parts **10** illustrated in FIG. **15** to FIG. **17** have a structure in which the twisted portion **25**P does not exist in the ring hole **30**A. Thus, the extra space due to existence of the twisted portion **25**P is not needed, and dimensions of the ring hole **30**A can be made small. This allows reducing dimensions of the coil part **10**.

Further, upon forming the connecting wire part **22**, the winding structure **200** having the part to be connecting wire **22**A as illustrated in FIG. **1** is used. Moreover, the part to be connecting wire **22**A is provided with the first coupling portion **221** and the second coupling portion **223**, and existence of the first coupling portion **221** and the second coupling portion **223** allows separating the interval defining portion **222** sufficiently from the first winding part **21** and the second winding part **23**. Thus, the interval defining portion **222** is not located at a position of the ring hole **30**A but can be located at a position separated from the ring hole **30**A, allowing reduction of dimensions of the ring hole **30**A. This allows reducing dimensions of the core body **30**, and also allows reducing dimensions of the coil part **10**.

Note that in the connecting wire part **22**, the first coupling portion **221** and the second coupling portion **223** exist besides the interval defining portion **222**, and by the first coupling portion **221** and the second coupling portion **223**, the interval defining portion **222** can be located at a position separated from the ring hole **30**A, and thus a disposition not causing interference of the interval defining portion **222** with the core body **30** can be realized.

Further, in the coil part **10** of this embodiment, a disposition is also possible such that the connecting wire part **22** is located within the range of seeing the first winding part **21** and the second winding part **23** of the coil winding **20** in a plan view. This allows realizing space reduction of the coil part **10**.

Further, in the above-described embodiment, the directions of edgewise bending of the first winding part **21**, the part to be connecting wire **22**A, and the second winding part **23** are all the same in the winding structure **200**. This facilitates formation of the winding structure **200**. Here, when the directions of edgewise bending are in reverse, a labor such as changing the direction of setting the flat wire H so as to reverse a front side and a rear side occurs, and complication of the structure of the bending machine, and the like occur. However, since the directions of edgewise bending are all the same in the winding structure **200** as described above, it is possible to simplify labor during processing. Further, use of a bending machine having a complicated structure can be avoided.

Further, in this embodiment, as illustrated in FIG. **1** and FIG. **2**, in the winding structure **200**, the terminal portion **211** of the first winding part **21** and the terminal portion **233** of the second winding part **23** are provided so that directions toward their respective front end sides are opposite directions from each other (the terminal portion **211** is on the X1 side and the terminal portion **233** is on the X2 side). Moreover, the terminal portion **211** is located on an outer peripheral side (Y2 side of the first winding part **21**) where the first winding part **21** and the second winding part **23** do not face each other, and the terminal portion **233** is located on the side (Y2 side of the second winding part **23**) where the first winding part **21** and the second winding part **23** face each other.

When the coil winding **20** is formed using such a winding structure **200**, it is possible to make the directions of the terminal portions **211**, **233** the same. In addition, it is possible to separate the terminal portion **211** and the terminal portion **233** in the Y direction. This facilitates mounting of the coil part **10**, and allows preventing occurrence of short circuit between these terminal portions **211**, **233** upon mounting.

Further, in this embodiment, the coil winding **20**A of the type illustrated in FIG. **6** can be formed from the winding structure **200** illustrated in FIG. **1**. Specifically, the first coupling portion **221** is provided with the planar extending portion **225** continuing to the interval defining portion **222** by forming an edgewise bending and the portion for twisting **224**A which becomes the twisted portion **224** by being twisted later. Then, by twisting the portion for twisting **224**A as illustrated in FIG. **6**, the twisted portion **224** can be formed. Further, by providing the twisted portion **224**, the interval defining portion **222** can be positioned on the Z1 side of the twisted portion **224**, realizing a disposition not causing interference with the core **31**.

Here, the portion for twisting **224**A is twisted so that the face (surface) of a side on which the flat wire H is not to be stacked faces toward an outer peripheral side of the first winding part **21** as the flat wire H proceeds from the first winding part **21** to the interval defining portion **222**. By realizing such twisting, when the first winding part **21** and the second winding part **23** are formed, it is possible to make the directions of their windings the same, and thus it is possible to facilitate formation of the winding structure **200**.

Note that when it is twisted in an opposite direction to the above-described twisting direction, the direction of winding of the second winding part **23** is opposite to that of the first winding part **21**, and there may occur a labor of reversing the

position to set the flat wire H in the bending machine, or the like. However, when the direction of winding of the second winding part **23** is further reversed with respect to the first winding part **21** as the opposite twisting direction, effects similar to those of this embodiment can be generated.

Further, in this embodiment, it is possible to form the coil winding **20**B of the type illustrated in FIG. **8**. Specifically, the coil winding **20**B can be formed using the winding structure **200** by bending the boundary portion between the first coupling portion **221** and the first winding part **21** so that the first coupling portion **221** is directed toward the Z direction (direction in parallel with the axial direction), and further bending the boundary portion between the second coupling portion **223** and the second winding part **23** so that the second coupling portion **223** is directed toward the Z direction. Further, since the coil winding **20**B is formed by just bending the winding structure **200**, the coil winding **20**B can be formed easily.

Moreover, in this embodiment, it is possible to form the coil winding **20**C of the type illustrated in FIG. **10**. Specifically, the boundary portion between the first coupling portion **221** and the first winding part **21** is bent so that an extending direction of the first coupling portion **221** is provided obliquely with respect to the axial direction (Z direction) of the first winding part **21**. In addition, the boundary portion between the second coupling portion **223** and the second winding part **23** is bent so that an extending direction of the second coupling portion **223** is provided obliquely with respect to the axial direction (Z direction) of the second winding part **23**.

Thus, the interval defining portion **222** can be located at a position on the outer peripheral side (X1 side) of the first winding part **21** and the second winding part **23** with respect to the bent portion, and hence a disposition not causing interference between the core body **30** and the interval defining portion **222** can be realized.

Modification Example

The winding structure **200**, the coil winding **20**, the coil part **10**, and the manufacturing method of the coil winding **20** according to one embodiment of the present invention have been described above. Besides them, the present invention can be modified in various ways. Such modifications will be described below.

In the above-described embodiment, the first winding part **21** and the second winding part **23** are wound in a rectangular shape. However, the first winding part **21** and the second winding part **23** are not limited to the structure of being wound in a rectangular shape, and may be wound in a different shape, such as a circle, an ellipse, or a polygon such as a triangle.

Further, in the above-described embodiment, the direction of bending the boundary portion between the first coupling portion **221** and the first winding part **21** and the direction of bending the boundary portion between the second coupling portion **223** and the second winding part **23** are provided to be opposite. However, the directions of bending these two boundary portions may be the same direction. In this case, one is right bending and the other is left bending between the edgewise bending when the first winding part **21** is formed and the edgewise bending when the second winding part **23** is formed.

Further, in the above-described embodiment, as illustrated in FIG. **2**, the interval defining portion **222** is structured to be located on the X1 side with respect to the straight portion **213***b*. Accordingly, the first coupling portion **221** is shorter than the straight portion **213***a*. However, the first coupling portion **221** may be formed to have about the same length as the straight portion **213***a* by providing the interval defining portion **222** at a position equivalent to the straight portion **213***b* in the X direction. In this case, the length of the second coupling portion **223** also becomes approximately the same length as the first coupling portion **221**. Further, the first coupling portion **221** may be formed to be longer than the straight portion **213***a* by providing the interval defining portion **222** on the X2 side with respect to the straight portion **213***b* in the X direction.

The winding structure, the coil winding, the coil part, and the coil winding manufacturing method of the present invention can be used in the field of electric equipment.

DESCRIPTION OF REFERENCE NUMERALS

10, **10**A to **10**C, **10**P . . . coil part
20, **20**A to **20**C, **20**P . . . coil winding
21, **21**P . . . first winding part
22, **22**P . . . connecting wire part
22A . . . part to be connecting wire
23, **23**P . . . second winding part
24 . . . center hole
25P . . . twisted portion
30 . . . core body
30A, **30**P . . . ring hole
31 . . . core
31*a* . . . cutout part
31*b* . . . leg portion
200 . . . winding structure
211 . . . terminal portion (corresponding to first terminal)
212*a* to **212***d* . . . bent portion
213*a* to **213***d* . . . straight portion
221 . . . first coupling portion
222 . . . interval defining portion, **223** . . . second coupling portion
224 . . . twisted portion
224A . . . portion for twisting
225 . . . planar extending portion
231*a* to **231***d* . . . bent portion
233 . . . terminal portion (corresponding to second terminal)
H . . . flat wire
M . . . bending part
P . . . processing unit
P1 . . . inner jig
P2 . . . outer jig

What is claimed is:

1. A coil winding, comprising:
a first winding part formed by winding a flat wire;
a second winding part formed by winding the flat wire continuing to the first winding part, the second winding part being wound in a same winding direction as a winding direction of the first winding part; and
a connecting wire part located between the first winding part and the second winding part to connect the winding parts, wherein
the connecting wire part comprises:
an interval defining portion defining an interval between the first winding part and the second winding part;
a first coupling portion with one end side continuing to the interval defining portion by forming an edgewise bending and another end side continuing to the first winding part on one side in an axial direction of the first winding part; and
a second coupling portion with one end side continuing to the interval defining portion by forming an edgewise

bending and another end side continuing to the second winding part on another side in an axial direction of the second winding part, wherein

the first coupling portion is continuing to the first winding part at the side opposite to the side facing the second winding part; and

the second coupling portion is continuing to the second winding part at the side opposite to the side facing the first winding part.

2. The coil winding according to claim **1**, wherein

the first coupling portion is provided with:

a planar extending portion continuing to the interval defining portion by forming an edgewise bending; and

a twisted portion which is located between the first winding part and the planar extending portion, wherein the flat wire is twisted so that the width of the flat wire extends in a direction to depart from the first winding part as the flat wire proceeds from the first winding part to the planar extending portion.

3. The coil winding according to claim **1**, wherein

a first terminal on a side opposite to the connecting wire part and a second terminal on a side opposite to the connecting wire part extend in a same direction as each other toward respective front end sides thereof, and

one of the first terminal and the second terminal is located on a facing portion side where the first winding part and the second winding part face each other, and the other of the first terminal and the second terminal is located on an outer peripheral side where the first winding part and the second winding part do not face each other.

4. The coil winding according to claim **1**, wherein

a boundary portion between the first coupling portion and the first winding part is bent so that the first coupling portion extends in a direction to depart from the first winding part,

a boundary portion between the second coupling portion and the second winding part is bent so that the second coupling portion extends in a direction to depart from the second winding part.

5. The coil winding according to claim **4**, wherein

the boundary portion between the first coupling portion and the first winding part is bent so that an extending direction of the first coupling portion is provided in substantially parallel with an axial direction of the first winding part, and

the boundary portion between the second coupling portion and the second winding part is bent so that an extending direction of the second coupling portion is provided in substantially parallel with an axial direction of the second winding part.

6. The coil winding according to claim **4**, wherein

the boundary portion between the first coupling portion and the first winding part is bent so that an extending direction of the first coupling portion is provided obliquely with respect to an axial direction of the first winding part, and

the boundary portion between the second coupling portion and the second winding part is bent so that an extending direction of the second coupling portion is provided obliquely with respect to an axial direction of the second winding part.

7. A coil part, comprising:

the coil winding according to claim **1**; and

a core body formed from a magnetic material, provided in a ring shape, and inserted through a center hole of the first winding part and a center hole of the second winding part.

8. A coil winding manufacturing method for forming a coil winding from a flat wire, the method comprising:

a first winding step comprising winding the flat wire to form a first winding part;

a part to be connecting wire forming step of comprising forming a part to be connecting wire continuing to the first winding part;

a second winding step comprising winding the flat wire in a same winding direction as a winding direction of the first winding part to form a second winding part continuing to the part to be connecting wire; and

a connecting wire part forming step comprising forming a connecting wire part from the part to be connecting wire, wherein

the part to be connecting wire forming step comprises:

a first feeding step comprising feeding, after the first winding step and before the second winding step, the flat wire farther than a bending part to provide a first fed portion continuing to the first winding part;

a first bending step comprising performing, at the bending part after the first feeding step, edgewise bending of the flat wire in the same direction as the winding direction of the first winding part to form a first coupling portion continuing to the first winding part at a side opposite to a side where the first winding part and the second winding part face each other;

a second feeding step of comprising feeding, after the first bending step, the flat wire to provide a second fed portion;

a second bending step comprising performing, at the bending part after the second feeding step, edgewise bending of the flat wire in the same direction as the winding direction of the first winding part to form an interval defining portion continuing to the first coupling portion and defining an interval between the first winding part and the second winding part; and

a third feeding step comprising feeding, after the second bending step, the flat wire farther than the bending part to provide a third fed portion with a second fed portion continuing to the interval defining portion and the second winding part at the side opposite to the side where the first winding part and the second winding part face each other.

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